"An Extension of Maxwell's Electro-magnetic Theory of Light to include Dispersion, Metallic Reflection, and Allied Phenomena." By EDWIN EDSER, A.R.C.S. Communicated by Captain W. DE W. ABNEY, C.B., F.R.S. Received February 18,—Read March 10, 1898.

(Abstract.)

A dielectric, like an electrolyte, is assumed to consist of molecules, each comprising, in the simplest case, two oppositely charged atoms at a definite distance apart. In a homogeneous medium, when not subjected to electric strain, these molecules will be arranged in such a manner that any element of volume will possess no resultant electric moment. If a definite potential difference be maintained between any two parallel planes in the medium, the positively charged atoms will move to points of lower, and the negatively charged atoms to points of higher, potential. Thus two kinds of molecular strain are produced: firstly, a molecular rotation; and secondly, a separation in the molecule of the constituent atoms. Let P be the actual electromotive intensity at any point in the medium, and D be the electric displacement other than that produced by the atomic charges. Then

$$P(1+4\pi M) = 4\pi D,$$

where M is a constant depending on the nature of the medium. The quantity $1+4\pi M$ represents the specific inductive capacity of the medium. The actual linear displacement of the atoms is shown to be small when compared with molecular magnitudes.

Maxwell's equation, expressing that the line integral of the electromotive intensity round a closed circuit is equal to the rate of decrease of the magnetic induction through the circuit, needs no modification when the propagation of disturbances through the above medium is considered. Maxwell's second equation is modified by adding to the total displacement current at any point the expression $\Sigma q v_x$, where q is the atomic charge, v_x is the velocity of that charge in the direction considered, and Σ denotes summation for unit volume.

Subsidiary equations for the atomic vibrations (rotational and separational) are given, and the refractive index is finally determined in the form

$$\mu^2 = \mu^2_\infty + \frac{c'\lambda_1^2}{\lambda^2-\lambda_1^2} + \frac{c''\lambda_2^2}{\lambda^2-\lambda_2^2},$$

which is the most general form of Ketteler's dispersion formula.

μ^2_∞ is found to be equal to the specific inductive capacity of the medium, as previously determined.

For a medium which might be compressed without altering the period of vibration of the constituent molecules, Gladstone and Dale's law, in the modified form $\mu^2 - 1 \propto$ density, would follow.

Double refraction, in case of a uniaxial crystal, is explained on the assumption that the molecules are arranged with their axes parallel to a certain direction. Electrical disturbances perpendicular to this direction will produce a molecular rotation, whilst those parallel to this direction will produce an inter-atomic separation. The doubly refracting nature of a dielectric when subjected to electric strain is thus explained; and it is pointed out that Lord Kelvin was led to postulate a crystalline structure similar to the above to account for the pyro-electric properties of tourmaline, &c.

For infinitely quick vibrations the refractive index of the above medium will be equal to unity, a result possibly explaining the action of material bodies on Röntgen radiations.

Assuming a metallic or quasi-metallic substance to have a structure essentially similar to that described above, with the addition that a viscous term is included in the equation for the atomic vibration, the refractive index of a metal is found in the form of a complex quantity, the imaginary part of which is essentially positive. The ordinary laws of metallic reflection, as deduced by Cauchy and others, will therefore hold. It is shown that for those metals in which the real part of the square of the refractive index is a large negative quantity, the velocity of propagation of light will be inversely proportional to the molecular viscosity. Since Mr. Tomlinson has shown that for those metals which he had examined the order of magnitude of the specific electrical resistances was the same as that of the molecular viscosities, a connection is established between the velocity of light and the electrical conductivity of a metal, agreeing with that obtained experimentally by Kundt.

The initial assumptions in the above investigation are similar to those made by Helmholtz in his papers on the "Electro-magnetic Theory of Dispersion."* Some doubt has been expressed as to whether Helmholtz's developments are in consonance with Maxwell's theory.† In the present case the principle of Least Action is not used. The dispersion formula obtained differs from that of Helmholtz, but bears a general resemblance to that obtained by Rieff in his modification of Helmholtz's theory.‡ A more definite physical significance is, however, given to the various constants introduced.

* 'Wied. Ann.,' vol. 48, pp. 389—405, 723—725.

† O. Heaviside, 'Electrician,' vol. 37, August 7, 1896.

‡ 'Wied. Ann.,' vol. 55, pp. 82—95.